Anticoagulation and Desired Hemostyptic Properties of Abdominal Swabs during Surgical Interventions

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Abstract

In clinical routine, abdominal swabs are used to retain organs and tissues as well as to inhibit blood flow during surgical interventions. However, in patients receiving systemic anticoagulation treatment, the hemostyptic potency of the deployed abdominal swabs is likely to be influenced. To investigate this hypothesis, the simple clotting test (SCT) was used, in which abdominal swabs are incubated with fresh human whole blood for 30 min at 37 °C. Our data show that increasing heparin concentrations not only prolong the measured blood activated clotting time and the activated partial thromboplastin time prior SCT, but also prevent macroscopic blood clot formation as well as reduce platelet loss during SCT. However, the formation of the sensitive coagulation marker thrombin-antithrombin III still occurs even when using up to 2 IU/ml heparin.

In conclusion, our data support the hypothesis that the hemostyptic potency of abdominal swabs are altered or even completely absent in patients receiving anticoagulation therapy.

Introduction

Abdominal swabs (class IIa medical devices, MDD 93/42/ECC) are routinely used during surgical interventions to hold and retain organs and tissues as well as to stem blood flow and absorb blood and exudate, which are all desired characteristics of abdominal swabs [1,2]. Due to the properties of the material, i.e. cotton, abdominal swabs possess slight coagulation-activating and thus hemostyptic properties [2]. This is a combination of physical action (suction, drying of the wound) and hemostasis-related activation mechanisms. In the case of the latter, the contact of the blood with the non-physiological surface of the swabs results in an activation of the intrinsic coagulation cascade [3].

In everyday clinical practice, patients are more likely to be permanently anticoagulated (with old or new anticoagulants) due to their age and severity of the disease even during surgical interventions. Hence, in patients undergoing systemic anticoagulation therapy, it is expected that the hemostyptic potency of abdominal swabs might be dependent on the degree of anticoagulation [4,5].

Material and Methods

To test this hypothesis, we analyzed the hemostyptic properties of abdominal swabs in relation to various anticoagulation levels using fresh human whole blood containing different concentrations of heparin and a well-established simple clotting test (SCT) [2].

Therefore, human whole blood was collected from six healthy volunteers by venipuncture, who provided written informed consent before sampling. The blood was anticoagulated with different concentrations of heparin (Ratiopharm GmbH, Germany). All subjects were free of platelet-affecting agents for ≥14 days. Blood sampling procedures were approved by the research and ethics unit of the University of Tuebingen, Germany. Activated clotting time (ACT) evaluation was performed directly after blood taking for baseline measurements using the Hemochrom Jr. II system (Life system, Germany). In addition, baseline blood samples of the different heparin concentrations were anticoagulated in sodium citrate tubes to measure the activated partial thromboplastin time (aPTT) according to manufacturer’s description using a coagulumeter (Amelung, Germany).

Furthermore, the SCT was performed directly after blood sampling as previously described [1]. Briefly, abdominal swabs (Toptex light green, Lohmann & Rauscher GmbH, Germany) were cut in pieces (1x4 cm) and inserted into 14 ml polypropylene round-bottom tubes (BD Falcon, USA) and incubated with 9 ml of blood, which was anticoagulated with different heparin concentrations ranging from 0.5 to 2.0 IU/ml. All tubes, as well as control tubes containing anticoagulated whole blood only, were incubated at 37 °C for 30 min at 20 rpm on an orbital shaker (Polymax 1040, Heidolph, Germany). After incubation and washing, macroscopic pictures of the abdominal swabs were taken to detect macroscopic blood clot formation.

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Before and after the SCT, the number of erythrocytes, leukocytes, platelets, as well as hemoglobin and hematocrit values were measured using a cell counter system (ABX Micros 60, Axon Lab AG, Switzerland). Thrombin-antithrombin III complexes (TAT) were determined as a plasmatic marker for coagulation using an enzyme-linked immunosorbent assay (ELISA, Siemens Healthcare, Germany) according to the manufacturer’s instructions.

Results

As expected, our data show that the blood ACT is prolonged with increasing heparin concentrations. Compared to non-anticoagulated blood (control) with an ACT of 123.8 ± 10.6 s, a significant increase in the ACT was detectable with heparin concentrations of 1.25 IU/ml (295.5 ± 31.0 s, p<0.05) or higher (Figure 1A). A significant increase in the aPTT was already measured in blood anticoagulated with 0.5 IU/ml heparin compared to control blood (375.2 ± 122.1 s vs. 25.62 ± 3.9 s, respectively, p<0.0001). aPTTs of blood anticoagulated with heparin concentrations ≥1.0 IU/ml were outside the measuring range (Figure 1B). After performing the SCT, it could also be shown that a heparin concentration of >1.0 IU/ml could significantly reduce macroscopic blood clot formation on abdominal swabs as exemplarily shown in Figure 1C for donor 1 and 4. In total, macroscopic blood clot formation was only detected in all 6 donors using heparin concentrations of 0.5 and 0.75 IU/ml and in 5 donors using heparin concentrations of 1.0 IU/ml, whereas no blood clot formation was observed in blood anticoagulated with >1.0 IU/ml (Figure 1D).

Irrespective of the presence of an abdominal swab or the pretreatment with varying heparin concentrations, blood count analysis shows that there are no significant differences in red blood cells (Figure 2A), hemoglobin (Figure 2B) and hematocrit (Figure 2C) values compared to baseline measurements. Since

![Figure 1](image)

**Figure 1.** Abdominal swabs showing significant differences in their procoagulant activity after incubation with different concentrations of heparin in whole human blood. (A) ACT and (B) aPTT baseline measurements. (C) Representative macroscopic images showing abdominal swabs after SCT performance with heparinized blood (n=6) compared to an abdominal swab w/o blood. (D) Overview of the positive (blood clot formation) and negative (no blood clot formation) SCT results. Data are depicted as means ± standard deviation (SD). Normally distributed data were analyzed using repeated measures ANOVA with Bonferroni’s multiple comparison test. Not normally distributed data were analyzed using a non-parametrical test (Friedman test with Dunn’s multiple comparison test). *p<0.05; **p<0.01; ****p<0.0001.
strong blood clotting was induced by abdominal swabs in blood anticoagulated with 0.5 and 0.75 IU/ml heparin, blood cell count was impractical in these samples.

However, the number of white blood cells and platelets was significantly decrease after the incubation of blood with abdominal swabs in all measurable heparin concentration groups (Figure 2D and E, p<0.0001). Nevertheless, the drop of platelet numbers was less pronounced during the presence of abdominal swabs in blood treated with heparin concentrations of ≥1.5 IU/ml when compared to the number of platelets measured in blood anticoagulated with 1.0 IU/ml heparin (Figure 2E).

In the baseline groups and the SCT control groups without abdominal swabs, all heparin concentrations inhibited the formation of TAT III complex and hence activation of blood coagulation (Figure 2F).

However, the incubation of heparinized blood with abdominal swab led to a significant increase in TAT III complex formation in all heparin concentration groups.

**Discussion**

As our data indicate, the employed abdominal swab decreased platelet and white blood cell count and induced blood clot formation that got diminished by heparin concentrations of ≥1.0 IU/ml, which corresponds to an ACT of 264.3 ± 19.19 s within our set-up.
Although the desired hemostyptic effect of abdominal swabs in the intended use has proven itself in clinical practice for decades, the situation might be different in the case of special surgical interventions. Thus, for example, the hemostyptic potency of the abdominal swabs can be reduced or completely absent in patients under high-dose heparinization during cardiac surgery using a heart-lung machine or in patients undergoing long-term systemic anticoagulation therapy. Hence, the individual situation of the patient needs to be considered in clinical practice. Nevertheless, further examinations of our findings in relations with other coagulants, like antiplatelet agents or warfarin, are required.

**Conflicts of Interest**

MA and AK are employees of Lohmann & Rauscher GmbH & Co KG, Germany. All other authors have declared that no competing interest exists.

**References**